

27 March 2026

IARC Monographs evaluate the carcinogenicity of tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide

IARC Monographs Volume 141

Questions and Answers (Q&A)

The meeting for *IARC Monographs* Volume 141: Tris(chloropropyl) Phosphate, Butyraldehyde, and Cumyl Hydroperoxide was convened by the International Agency for Research on Cancer (IARC) in Lyon, France, and took place on 3–10 March 2026.

At the meeting, the Working Group of 12 [international experts](#) from nine countries finalized their evaluation of the carcinogenicity of three high-production-volume chemicals: tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide.

More information about the meeting is available on the *IARC Monographs* website:

<https://monographs.iarc.who.int/iarc-monographs-volume-141/>.

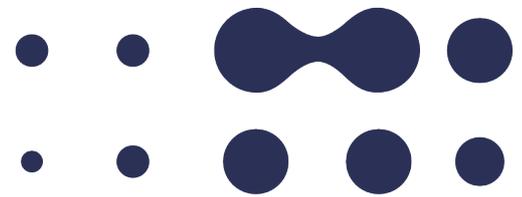
The outcome of the assessment has been published in a summary article in *The Lancet Oncology*¹ and will be described in detail in Volume 141 of the *IARC Monographs*, to be published in 2027.

1. What agents were evaluated in *IARC Monographs* Meeting 141?

The Working Group for *IARC Monographs* Volume 141 evaluated the carcinogenicity of three chemicals: tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide.

Tris(chloropropyl) phosphate (TCPP): TCPP is a high-production-volume chemical that is widely used as a flame retardant in many consumer products, including polyurethane foams in furniture and mattresses, textiles, plastics, and construction material such as insulation products and sealants. It is found in many places in the environment, but levels are often higher indoors because it can accumulate in household dust, which acts as a reservoir.

¹ Lachenmeier DW, Arrandale VH, DeMarini DM, Ruksha T, Abdallah MA, Bettini G, et al. Carcinogenicity of tris(chloropropyl) phosphate, butyraldehyde, and cumyl hydroperoxide. *Lancet Oncol*. Published online 27 March 2026; [https://doi.org/10.1016/S1470-2045\(26\)00168-3](https://doi.org/10.1016/S1470-2045(26)00168-3)



Butyraldehyde: Butyraldehyde is a high-production-volume chemical. It occurs naturally in plants, as a combustion product, and as an endogenous metabolite produced in small amounts in the human body. More than 90% of production is used on-site as a chemical intermediate to make other chemicals, mainly *n*-butanol, butyric acid, 2-ethylhexanol, polyvinyl butyral, and plasticizers. Smaller amounts are used in flavourings, fragrances, pharmaceuticals, agrochemicals, and antioxidants.

Cumyl hydroperoxide: Cumyl hydroperoxide is a high-production-volume chemical. It is used as a catalyst and curing agent and as an intermediate in the production of acetone and phenol.

2. Who is exposed to these agents?

TCP: Occupational exposure is highest in workers producing or handling foam containing TCP but may also occur in workplaces such as offices, through furnishings and electronic and electrical equipment.

In the general population, exposure to TCP is widespread and is highest in young children with frequent hand-to-mouth behaviour. It occurs through indoor air and dust, consumer products, and food. TCP can enter the body via ingestion, inhalation, and dermal contact.

Butyraldehyde: Occupational exposure can occur during the production and use of TCP in chemical manufacturing, food service, health care, firefighting, and charcoal production, although quantitative measurements are limited.

The general population is exposed through cigarette smoke, ambient air, and the diet, including natural food sources, flavouring uses, and cooking-related formation.

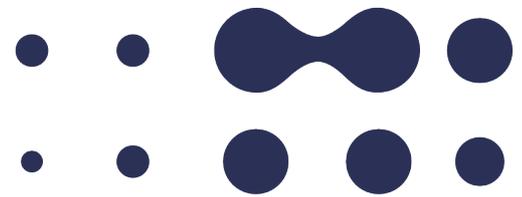
Cumyl hydroperoxide: Occupational exposure may occur via inhalation or dermal contact during manufacturing and handling.

No data were available for exposure of the general population.

3. Have these agents been evaluated before? Why did IARC evaluate them now?

None of these chemicals have been previously evaluated by the *IARC Monographs* programme. TCP, butyraldehyde, and cumyl hydroperoxide were each accorded high priority for evaluation by the [Advisory Group to Recommend Priorities for the IARC Monographs during 2025–2029](#).² TCP and butyraldehyde were the subject of a recent relevant cancer bioassay, and cumyl hydroperoxide was the subject of relevant mechanistic evidence.

² IARC (2024). Report of the Advisory Group to Recommend Priorities for the *IARC Monographs* during 2025–2029. Lyon, France: International Agency for Research on Cancer. Available from: https://monographs.iarc.who.int/wp-content/uploads/2024/11/AGP_Report_2025-2029.pdf.



4. What are the results of the evaluation?

The results of the evaluation are summarized in Table 1.

Table 1. Summary of classifications in IARC Monographs Volume 141

Agent	Evidence stream			Overall evaluation
	Cancer in humans	Cancer in experimental animals	Mechanistic evidence	
Tris(chloropropyl) phosphate (TCPP)	<i>Inadequate</i>	<i>Sufficient</i>	<i>Strong</i> (in human primary cells and in experimental systems)	Group 2A
Butyraldehyde	<i>Inadequate</i>	<i>Sufficient</i>	<i>Strong</i> (in experimental systems)	Group 2B
Cumyl hydroperoxide	<i>Inadequate</i>	<i>Limited</i>	<i>Strong</i> (in human primary cells and in experimental systems)	Group 2B

5. How did the Working Group reach these results?

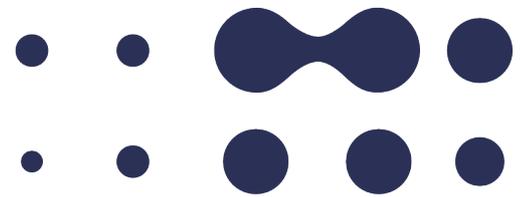
TCPP was classified as *probably carcinogenic to humans* (Group 2A) on the basis of the combination of *sufficient* evidence for cancer in experimental animals and *strong* mechanistic evidence in human primary cells. There was also *strong* mechanistic evidence in experimental systems. For TCPP, the evidence regarding cancer in humans was *inadequate*.

Butyraldehyde was classified as *possibly carcinogenic to humans* (Group 2B) in two ways: (i) via *sufficient* evidence for cancer in experimental animals; and (ii) via *strong* mechanistic evidence in experimental systems. For butyraldehyde, the evidence regarding cancer in humans was *inadequate*.

Cumyl hydroperoxide was classified as *possibly carcinogenic to humans* (Group 2B) on the basis of *strong* mechanistic evidence in human primary cells and experimental systems. For cumyl hydroperoxide, the evidence for cancer in experimental animals was *limited*, and the evidence regarding cancer in humans was *inadequate*.

6. Why are these results important?

Identifying the causes of human cancer is the first step in cancer prevention. Cancer prevention is needed because the global burden of cancer is high and continues to increase because of population growth and ageing, and upward trends in some exposures, especially in low- and middle-income countries. The identification of a cancer hazard may have broad and profound implications. National and international authorities and organizations can and do use information on the causes of cancer to support actions to reduce



exposure to carcinogens in the workplace, in the environment, and elsewhere. They may implement precautionary measures or decide to conduct a risk assessment to better determine the level of risk under specific conditions of use.

7. How was the Group 2A classification reached for TCPP?

The Working Group reached a Group 2A classification for TCPP on the basis of the combination of *sufficient* evidence for cancer in experimental animals and *strong* mechanistic evidence in human primary cells. There was also *strong* mechanistic evidence in experimental systems, and the evidence regarding cancer in humans was *inadequate*.

There was *sufficient* evidence that TCPP causes cancer in experimental animals. Oral treatment with TCPP led to an increase in the incidence of either malignant neoplasms or an appropriate combination of benign and malignant neoplasms in both sexes of two species (mouse and rat) in two well-conducted studies that complied with Good Laboratory Practice (GLP). There was *strong* mechanistic evidence in human primary cells that TCPP exhibits the key characteristics of carcinogens “is genotoxic” and “induces oxidative stress”. There was *strong* mechanistic evidence in experimental systems that TCPP exhibits the key characteristics of carcinogens “is genotoxic”, “induces oxidative stress”, “induces chronic inflammation”, “modulates receptor-mediated effects”, and “alters cell proliferation, cell death, and nutrient supply”.

8. How was the Group 2B classification reached for butyraldehyde?

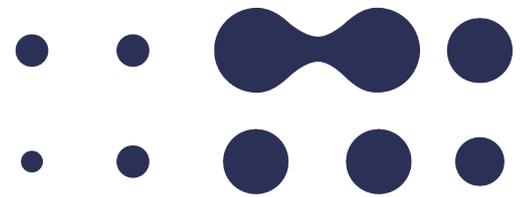
The Working Group reached a Group 2B classification for butyraldehyde in two ways: (i) via *sufficient* evidence for cancer in experimental animals; and (ii) via *strong* mechanistic evidence in experimental systems. The evidence regarding cancer in humans was *inadequate*.

There was *sufficient* evidence that butyraldehyde causes cancer in experimental animals. Administration of butyraldehyde by inhalation (whole body) led to an increase in the incidence of either malignant neoplasms or an appropriate combination of benign and malignant neoplasms in both sexes of one species (rat) in one well-conducted study that complied with GLP. There was *strong* mechanistic evidence in experimental systems (rodents) that butyraldehyde exhibits the key characteristics of carcinogens “induces chronic inflammation” and “alters cell proliferation, cell death, and nutrient supply”, which was supported by evidence in human primary cells.

9. How was the Group 2B classification reached for cumyl hydroperoxide?

The Working Group reached a Group 2B classification for cumyl hydroperoxide on the basis of *strong* mechanistic evidence in human primary cells and experimental systems. There was also *limited* evidence for cancer in experimental animals, and the evidence regarding cancer in humans was *inadequate*.

There was *strong* mechanistic evidence that cumyl hydroperoxide exhibits the key characteristics of carcinogens “is genotoxic” and “induces oxidative stress” in human primary cells and in experimental systems, and that it exhibits the key characteristics of carcinogens “induces chronic inflammation” and “alters cell



proliferation, cell death, and nutrient supply” in experimental systems. There was *limited* evidence that cumyl hydroperoxide causes cancer in experimental animals. Oral treatment with cumyl hydroperoxide led to an increase in the incidence of either malignant neoplasms or an appropriate combination of benign and malignant neoplasms in one sex (female) of one species (mouse) in two initiation–promotion studies.

10. Are these chemicals banned or restricted in any countries?

All three chemicals are high-production-volume chemicals. The use of TCPP in children’s toys and some other consumer products is restricted in the European Union. Butyraldehyde is permitted as a food flavouring agent in both the USA and the European Union. Occupational exposure limits for butyraldehyde have been established in several countries.

11. The general population is exposed to TCPP via the diet, air, and dust, and to butyraldehyde mainly via the diet, and via cigarette smoke in smokers. How significant are the risks for the general population?

The *IARC Monographs* classification indicates the strength of the evidence that a substance or agent can cause cancer. The *IARC Monographs* programme seeks to identify cancer hazards, meaning agents with the potential for the exposure to cause cancer. However, the classification does not indicate the level of cancer risk associated with exposure at different levels or in different scenarios. The cancer risk associated with substances or agents that are assigned the same classification may be very different, depending on factors such as the type and extent of exposure and the size of the effect of the agent at a given exposure level.

12. How can the public reduce their exposure?

IARC is a research organization that generates and evaluates evidence related to the causes of cancer but does not make health recommendations. However, the evaluations made by the *IARC Monographs* programme are often used as a basis for national and international policies, guidelines, and recommendations to minimize cancer risks.

13. How widely are these substances used and produced?

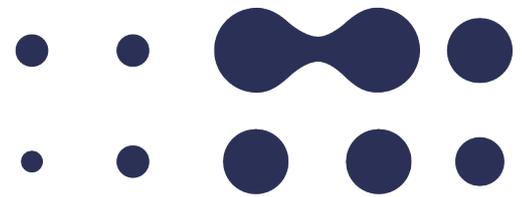
TCPP, butyraldehyde, and cumyl hydroperoxide are each listed as high-production-volume chemicals by the Organisation for Economic Co-operation and Development and the United States Environmental Protection Agency.

14. Are these substances persistent in the environment?

TCPP is considered to be a persistent compound with an environmental half-life of several months, depending on the environmental compartment (e.g. air, water, soil).

Butyraldehyde is not persistent in the environment and has an environmental half-life of up to several days.

Cumyl hydroperoxide is not persistent in the environment.



15. On the basis of this evaluation, what recommendations does IARC make?

IARC is a research organization that generates and evaluates evidence related to the causes of cancer but does not make health recommendations. However, the evaluations made by the *IARC Monographs* programme are often used as a basis for national and international policies, guidelines, and recommendations to minimize cancer risks.

You can find more information on the *IARC Monographs* evaluation process here:

https://monographs.iarc.who.int/wp-content/uploads/2018/07/QA_ENG.pdf.

16. What does the *IARC Monographs* classification mean in terms of risk?

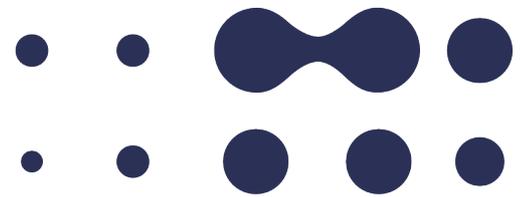
The *IARC Monographs* classification indicates the strength of the evidence that a substance or agent can cause cancer in humans. The *IARC Monographs* programme seeks to identify cancer hazards, meaning agents with the potential to cause cancer. However, the classification does not indicate the level of cancer risk associated with exposure at different levels or in different scenarios. The cancer risk associated with substances or agents that are assigned the same classification may be very different, depending on factors such as the type and extent of exposure and the size of the effect of the agent at a given exposure level.

17. What are the different strength-of-evidence evaluation groups used by the *IARC Monographs*?

The strength-of-evidence groups that contribute to each evaluation are summarized in Table 2.

Table 2. Strength-of-evidence groups used by the *IARC Monographs*

Evidence of Cancer in Humans	Evidence of Cancer in Experimental Animals	Mechanistic Evidence	Evaluation
Sufficient			Carcinogenic (Group 1)
	Sufficient	Strong (exposed humans)	
Limited	Sufficient		Probably carcinogenic (Group 2A)
Limited		Strong	
	Sufficient	Strong (human cells or tissues)	
		Strong (mechanistic class)	Possibly carcinogenic (Group 2B)
Limited			
	Sufficient		Not classifiable (Group 3)
		Strong	
	Sufficient	Strong (does not operate in humans)	Not classifiable (Group 3)
All other situations not listed above			



18. What are the four different categories into which agents are classified by the IARC Monographs?

Group 1: The agent is *carcinogenic to humans*.

This category is used when there is *sufficient* evidence for cancer in humans. In other words, there is convincing evidence that the agent causes cancer in humans. The evaluation is usually based on the results of epidemiological studies showing the development of cancer in exposed humans. Agents can also be classified in Group 1 on the basis of *sufficient* evidence for cancer in experimental animals supported by *strong* evidence in exposed humans that the agent has mechanistic effects that are important for cancer development.

Group 2:

This category includes agents with a range of evidence regarding cancer in humans and experimental animals. At one extreme of the range are agents with positive but not conclusive evidence regarding cancer in humans. At the other extreme are agents for which evidence in humans is not available but for which there is *sufficient* evidence for cancer in experimental animals. There are two subcategories, which indicate different levels of evidence.

Group 2A: The agent is *probably carcinogenic to humans*.

This category is used in four different scenarios:

1. When there is *limited* evidence for cancer in humans and *sufficient* evidence for cancer in experimental animals (*“limited”* evidence for cancer in humans” means that a positive association has been observed between exposure to the agent and cancer but that other explanations for the observations, technically termed “chance”, “bias”, or “confounding”, could not be ruled out with reasonable confidence);
2. When there is *limited* evidence for cancer in humans and *strong* mechanistic evidence;
3. When there is *sufficient* evidence for cancer in experimental animals and *strong* mechanistic evidence in human primary cells or tissues;
4. When, based on mechanistic considerations, the agent belongs to a class of agents of which one or more is *probably carcinogenic to humans* (Group 2A) or *carcinogenic to humans* (Group 1).

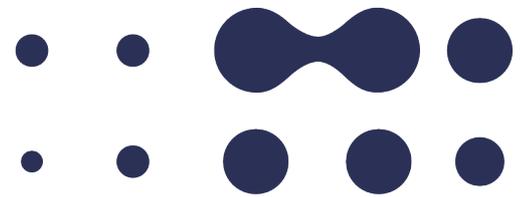
These scenarios may also occur simultaneously within a Group 2A classification.

Group 2B: The agent is *possibly carcinogenic to humans*.

This category is used when there is *limited* evidence for cancer in humans and less-than-*sufficient* evidence for cancer in experimental animals. It may also be used when the evidence regarding cancer in humans does not permit a conclusion to be drawn (referred to as *inadequate* evidence) but there is *sufficient* evidence for cancer in experimental animals. It can also be used when there is *strong* mechanistic evidence.

Group 3: The agent is *not classifiable as to its carcinogenicity to humans*.

This category is used most commonly when the evidence is *inadequate* regarding cancer in humans and *inadequate* or *limited* for cancer in experimental animals, and mechanistic evidence is less than *strong*.



“*Limited* evidence for cancer in experimental animals” means that the available information suggests a carcinogenic effect but is not conclusive.

19. How was the evidence reviewed in the *IARC Monographs* evaluation?

During an *IARC Monographs* evaluation, experts critically review the scientific evidence according to strict criteria, which focus on determining the strength of the available evidence that the agent causes cancer. These criteria are described in the Preamble to the *IARC Monographs*, which is available on the *IARC Monographs* website: <https://monographs.iarc.who.int/wp-content/uploads/2019/07/Preamble-2019.pdf>.

The experts critically review four types of data:

- the situations in which people are exposed to the agent;
- epidemiological studies on cancer in humans exposed to the agent (scientific evidence regarding cancer in humans);
- experimental studies of cancer in laboratory animals treated with the agent (scientific evidence regarding cancer in experimental animals); and
- studies on how cancer develops in response to the agent (scientific evidence on carcinogen mechanisms).

For more information, please contact:

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The International Agency for Research on Cancer (IARC) is part of the World Health Organization. Its mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control. The Agency is involved in both epidemiological and laboratory research and disseminates scientific information through publications, meetings, courses, and fellowships.

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